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TECHNICAL NOTES

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 566

TANK TESTS OF A MODEL OF THE NC FLYING-BOAT HULL - N.A.C.A. MODEL 44

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Washington
May 1936

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SUMMARY

A 1/7.06 full-size model of the NC-type hull was tested in the N.A.C.A. tank by both the general method and the specific or free-to-trim method. The results of the tests are given in curves plotted as nondimensional coefficients and are compared with the test results of N.A.C.A. model 11-A.

The NC model (N.A.C.A. model 44) shows higher resistance than model 11-A at hump speed but lower resistance at high speeds. Model 44 has a higher best trim angle at the hump and a lower maximum positive trimming moment than model 11-A. At high speeds the best trim angle and the trimming moments of the two models are approximately the same.

INTRODUCTION

The NC flying boats were designed during the World War for use in antisubmarine patrol in European waters. Because of the shortage of shipping and the loss of time involved in shipment and re-erection, these flying boats were designed to cross the Atlantic under their own power. The first NC flying boat was completed too late for service in the war but in 1919 the NC-4 demonstrated the ability of the type to accomplish the latter phase of its mission by making the first crossing of the Atlantic by air. The NC-4 is shown in flight in figure 1.

The performance of the hull used on the NC flying boats was so much better than that of earlier and contemporary hulls that the NC hull became and remains a basis of comparison for U.S. Navy flying-boat hulls. Present-day flying-boat hulls still show the influence of the NC design.

In view of the remarkable performance of this hull for its time and because of its influence on the development of the hulls of American flying boats, it was included in the series of historic hulls tested in the N.A.C.A. tank. These data and the data from similar tests will make the lessons learned by past experience available to present and future designers of seaplane hulls.

The Bureau of Aeronautics, Navy Department, has cooperated with the Committee by furnishing the lines of the original NC hull and by approving the tests and the publication of the test results.

THE MODEL

A 1/7.06 full-size model of the NC flying-boat hull was made for the tank tests and was designated N.A.C.A. model 44. The offsets for the model were obtained by scaling a 1/12 full-size drawing of the lines of the NC hull, converting the dimensions to model size and refairing. The scale of model 44 was selected to make the beam equal to that of N.A.C.A. model 11-A and to a number of other models that have been tested in the N.A.C.A. tank.

The principal lines of model 44 are shown in figure 2 and the offsets in table I. Two views of the model are shown by photographs in figure 3. The model was made of laminated mahogany to a tolerance of ±0.02 inch. It was painted with several coats of gray varnish and rubbed to give a smooth surface.

APPARATUS AND METHODS

The N.A.C.A. tank and associated equipment are discussed in detail in reference 1. The apparatus used in making this test was as described, except for changes in the method of suspending the towing gear and the method of measuring trimming moments. The method of suspending the towing gear is discussed in reference 2. The present trimming-moment gear consists of a stiff calibrated spring, the deflections of which are measured by a dial indicator.

Model 44 was tested by both the general method and the free-to-trim or specific method (reference 1). The towing force was applied to the model at a point corresponding to the center of gravity of the complete flying boat. The model was balanced about the towing point to give zero trimming moment at all trim angles in the free-to-trim test.

RESULTS

All the test results of model 44 are presented in the form of nondimensional coefficients, defined as follows:

Load coefficient, $C_\Delta = \Delta/wb^3$

Resistance coefficient, $C_R = R/wb^3$

Speed coefficient, $C_V = V/\sqrt{gb}$

Trimming-moment coefficient, $C_M = M/wb^4$

where Δ is the load on the water, lb.

R, resistance, lb.

M, trimming moment, lb./ft.

w, specific weight of water, lb./cu.ft.

b, beam of hull, ft.

V, speed, ft./sec.

g, acceleration of gravity, ft./sec.^{2}

Note: w = 63.5 lb./cu.ft. for water in the N.A.C.A. tank at the time of the test.

Curves of the resistance and trimming-moment coefficients for each load condition plotted against speed coefficient at each trim angle investigated in the general test are shown in figures 4 to 9.

Curves of resistance coefficient, load coefficient, and trim angle against speed coefficient for the free-to-trim test are shown in figure 10. These curves correspond to a full-scale gross weight of 28,000 pounds and a get-away speed of 58 miles per hour.

Curves of trimming-moment coefficient and draft-beam ratio at rest for various trim angles and loads are given in figure 11. These curves, plotted from tank data, furnish a means for the determination of water lines and longitudinal righting moments at rest for a wide range of loads and positions of the center of gravity.

The general test results were cross-plotted in the usual manner to determine the best trim angle (the trim angle corresponding to minimum resistance) and the resistance and trimming-moment coefficients at best trim angle. The resistance coefficient at best trim angle is plotted against speed coefficient in figure 12 and against load coefficient in figure 13. The variation of best trim angle with speed coefficient is shown in figure 14. Trimming moments at best trim angle are represented by curves of trimming-moment coefficient against speed coefficient in figure 15.

DISCUSSION OF RESULTS

The performance of model 11-A (reference 3) has been used as a basis for comparing data from a number of tank tests and is therefore used for comparison with model 44. Model 11-A is not representative of the latest hull designs but furnishes a connecting link for the results of several tests.

The test data of model 11-A used in the present comparison are not the same as those presented in reference 3 but are data from a later test made with the towing gear used in the present tests. The trimming-moment data given in this comparison are correct for a center of moments 8.15 inches forward of the step and 16.57 inches above the keel at the step for both models.

The difference in the shape of the decks of the models compared and the absence of a tail appendage on model 44 have little effect on tank results. Wind-tunnel tests of the two models (reference 4) show model 11-A to have a slightly higher air drag than model 44, but this difference in air drag was found to be much less than the difference in resistances found in the tank tests. The effect of the tail appendage is negligible because the tail appendage is in the water only at low speeds with high trim angles.

The resistances of models 44 and 11-A are compared in figure 16, which shows the variation of the load-resistance ratio with load coefficient at several speeds. The comparison shows model 44 to have higher resistance than model 11-A at the hump and at a speed coefficient of 3.5, which represents a speed slightly above the hump speed. Model 44, however, has lower resistance than model 11-A at high speeds.

Figure 17 shows that the best trim angle τ_o of model 44 is greater than that of model 11-A at hump speed but that it is about the same as that of model 11-A at higher speeds.

A comparison of the trimming-moment coefficients at best trim angle for models 44 and 11-A (fig. 18) shows that the maximum positive trimming moment at best trim angle is lower for model 44 than for 11-A. The trimming moments at higher speeds are about the same for both models and are near zero for best trim angle. The relative magnitudes of the maximum positive trimming moments show that model 44 is easier to hold near best trim angle than model 11-A.

Representative spray photographs of model 44 are shown in figure 19.

CONCLUDING REMARKS

The NC form (model 44) compares favorably with model 11-A in all respects except the hump resistance. This higher hump resistance, however, is offset by the lower resistance at high speeds. Although model 11-A does not represent exactly the form of any of the latest flying-boat hulls, it is a fair approximation and its performance in tank tests has been comparatively good.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., April 1, 1936.

REFERENCES

1. Truscott, Starr: The N.A.C.A. Tank - A High-Speed Towing Basin for Testing Models of Seaplane Floats. T.R. No. 470, N.A.C.A., 1933.

2. Shoemaker, James M.: Tank Tests of Flat and V-Bottom Planing Surfaces. T.N. No. 509, N.A.C.A., 1934.

3. Parkinson, John B.: A Complete Tank Test of a Model of a Flying-Boat Hull - N.A.C.A. Model No. 11-A. T.N. No. 470, N.A.C.A., 1933.

4. Hartman, Edwin P.: The Aerodynamic Drag of Flying-Boat Hull Models as Measured in the N.A.C.A. 20-Foot Wind Tunnel - I. T.N. No. 525, N.A.C.A., 1935.

TABLE I

Offsets for N.A.C.A. Model 44 Flying-Boat Hull (Inches)

Station	Distance from F.P.	Distance from base line: Keel	B1 [1] 1.70	B2 3.40	B3 5.10	B4 6.80	Chine	Deck	Half-breadths: Chine	WL2 [2] 9.92	WL4 8.19	WL6 6.46	WL8 4.73	WL10 3.00	WL12 1.27	Base line
F.P.	0.00	0.00						-0.18								0.00
1/4	.85	4.50	0.23											0.93	1.44	1.72
1/2	1.70	6.55	3.51				2.66		2.09			0.30	1.22	1.92	2.12	2.15
3/4	2.55	7.39	4.73				3.06		2.82			.67	1.70	2.81	2.59	2.20
1	3.40	7.84	 5.41	2.92 3.48			3.44	.18	3.44			.93	2.26	3.41	2.92	1.90
2	6.80	9.21	.21 7.47	1.04 6.10	3.42 5.08		4.92	.00	5.40		0.97	2.94	5.37	4.96	3.69	
3	10.20	10.26	.15 8.99	.77 7.89	2.05 6.92		6.18		6.74	0.45	2.90	6.07	6.46	5.80	4.20	
4	13.60	11.06	.15 10.10	.67 9.20	1.68 8.32	3.80 7.51	7.21		7.61	2.05	5.34	7.54	7.18	6.34	4.52	
5	17.00	11.65	.15 10.86	.64 10.09	1.52 9.30	3.20 8.51	7.96		8.10	3.75	7.54	8.03	7.59	6.66	4.71	
6	20.40	12.09	.15 ← Straight	.62	1.47 line	3.00 →	8.51		8.37		8.37	8.24	7.79	6.80	4.77	
7	23.80	12.39	.15	.62	1.47	3.00	8.87		8.47		8.47	8.32	7.83			
8	27.20	12.60	.15	.62	1.47	3.00	9.08		8.50		8.50	8.34				
9	30.60	12.75	.15	.62	1.47	3.00	9.23									
10	34.00	12.86	.15	.62	1.47	3.00	9.34									
11	37.40	12.93	.15	.62	1.47	3.00	9.41									
12	40.80	12.97	.15	.62	1.47	3.00	9.45		8.50		8.50					
13	44.20	12.99	.15	.62	1.47	3.00	9.48		8.48		8.48	8.34	7.83	6.80		
Step, F Step, A	46.90	13.00 12.47					9.50 8.97		8.45							
14	47.60	12.41	.15	.62	1.47	3.06	8.92		8.43		8.43	8.28	7.77	6.75		
15	51.00	12.11	.15	.62	1.47	3.13	8.68		8.29		8.29	8.14	7.65	6.70	4.77	
16	54.40	11.81	.16	.63	1.55	3.44	8.50		8.00		8.00	7.86	7.41	6.52	4.68	
17	57.80	11.51	.21	.75	1.82	4.30	8.41	.00	7.49		7.49	7.37	6.96	6.14	4.35	
18	61.20	11.22	.45	1.15	2.57		8.45	.20	6.70		6.70	6.58	6.20	5.41	3.58	
19	64.60	Straight line 10.92	.98	1.96	4.65		8.61	.67	5.57		5.57	5.47	5.12	4.33	2.36	
20	68.00	10.62	1.85	3.86			8.90	1.37	4.16		4.16	4.03	3.70	2.94		
21	71.40	10.32	3.73				9.28	2.25	2.51		2.46	2.30	2.00	1.35		
22	74.80	10.02					9.73		.71		.55	.33				
A.P.	76.10	9.91							.11							

[1] Distance from center line (plane of symmetry) to buttock (section of hull surface made by a vertical plane parallel to plane of symmetry).

[2] Distance from base line to water line (section of hull surface made by a horizontal plane parallel to base line).

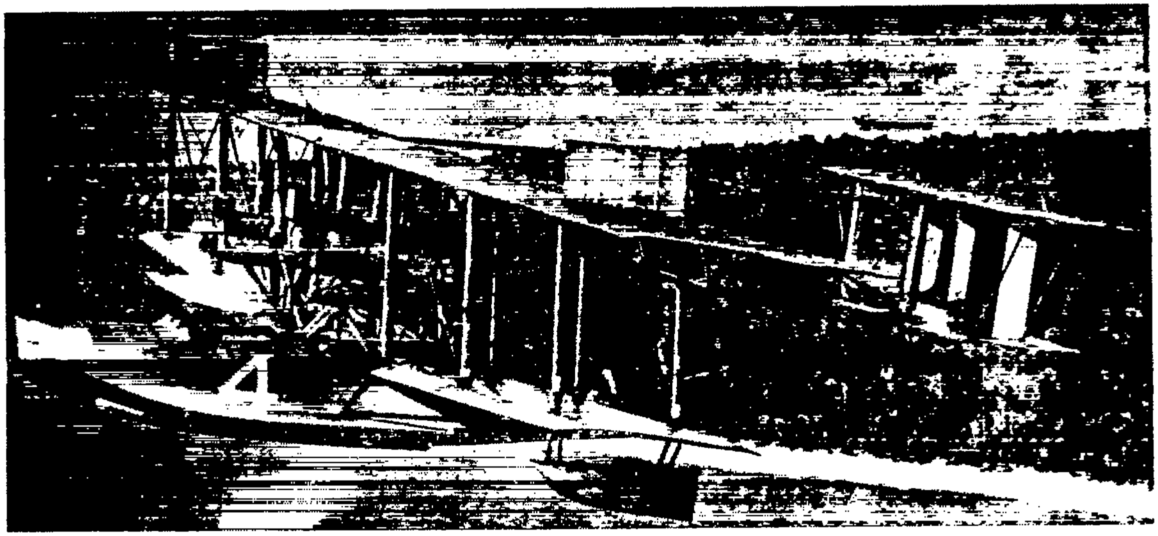


Figure 1.- The N C-4 in flight.

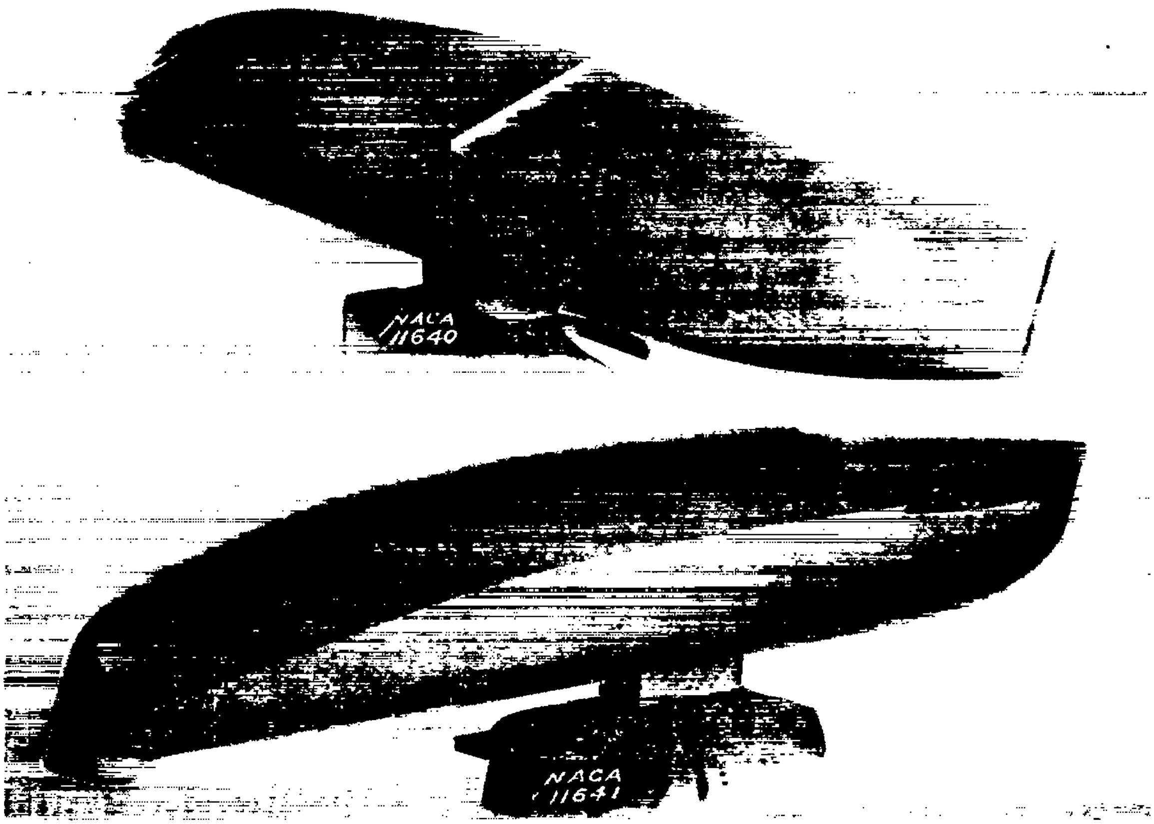


Figure 3.- N.A.C.A. model 44

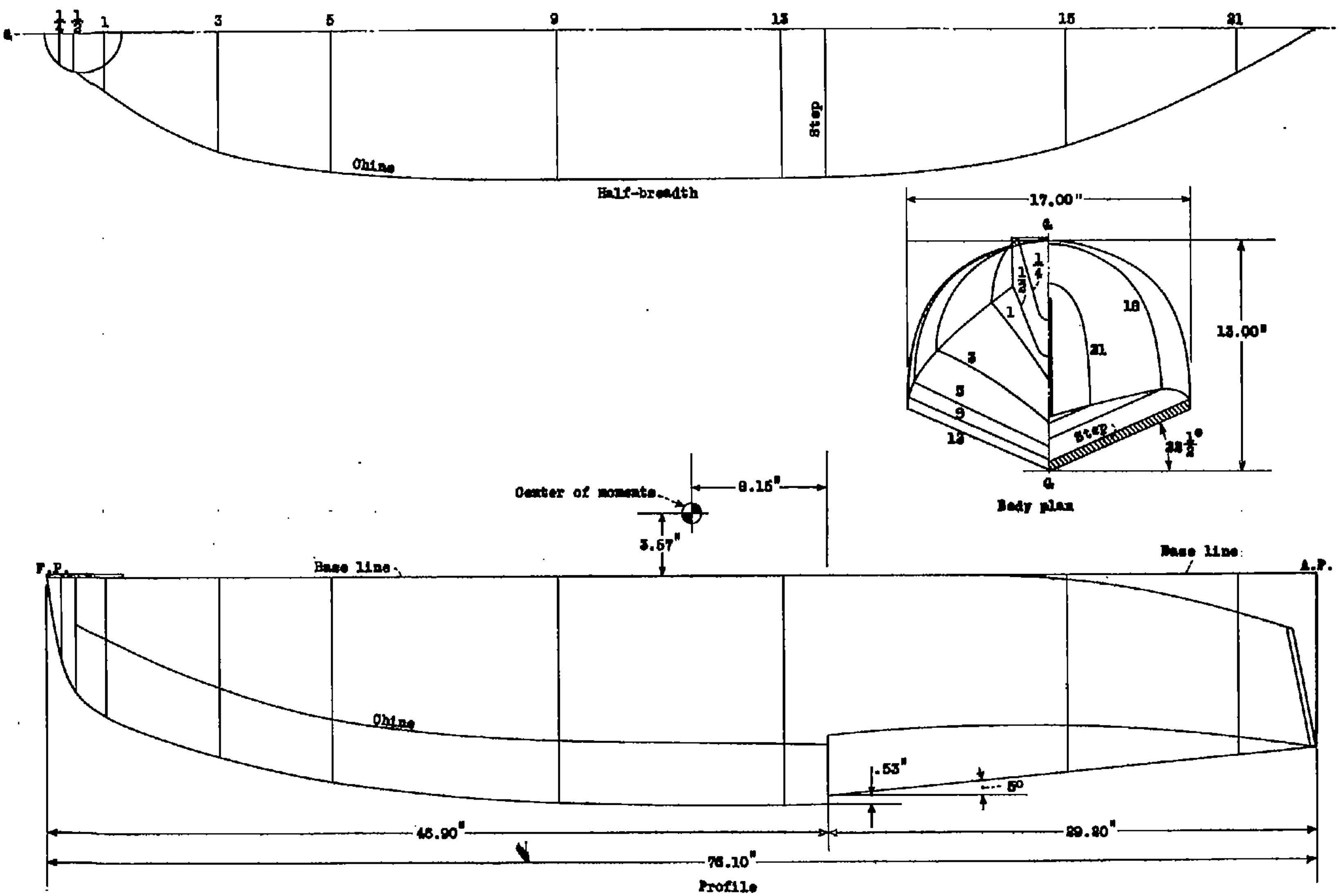


Figure 2.- Lines of N.A.C.A. Model 44 (NC hull).

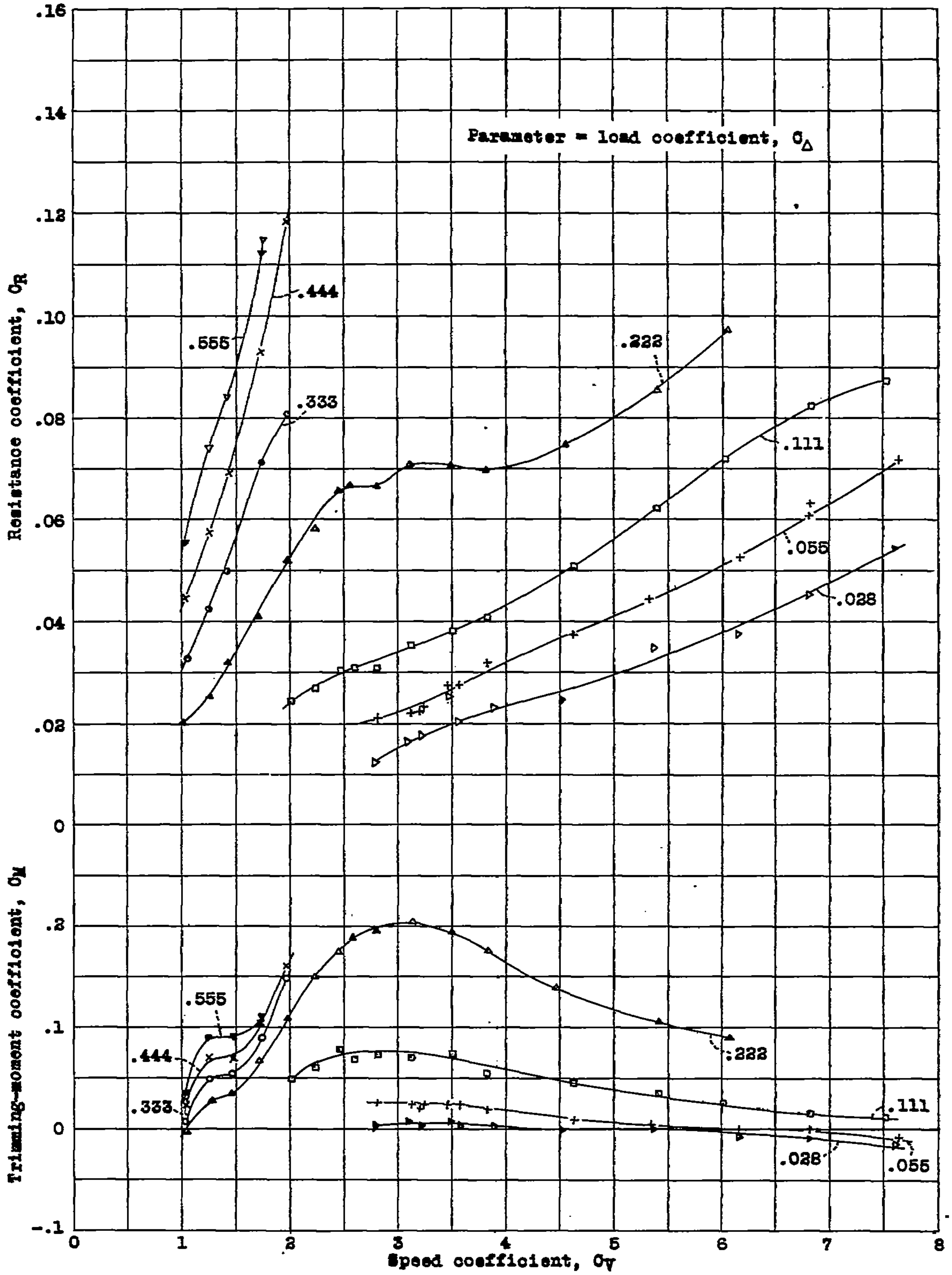


Figure 4.- Variation of C_R and C_M with C_V. τ = 2°. Model 44.

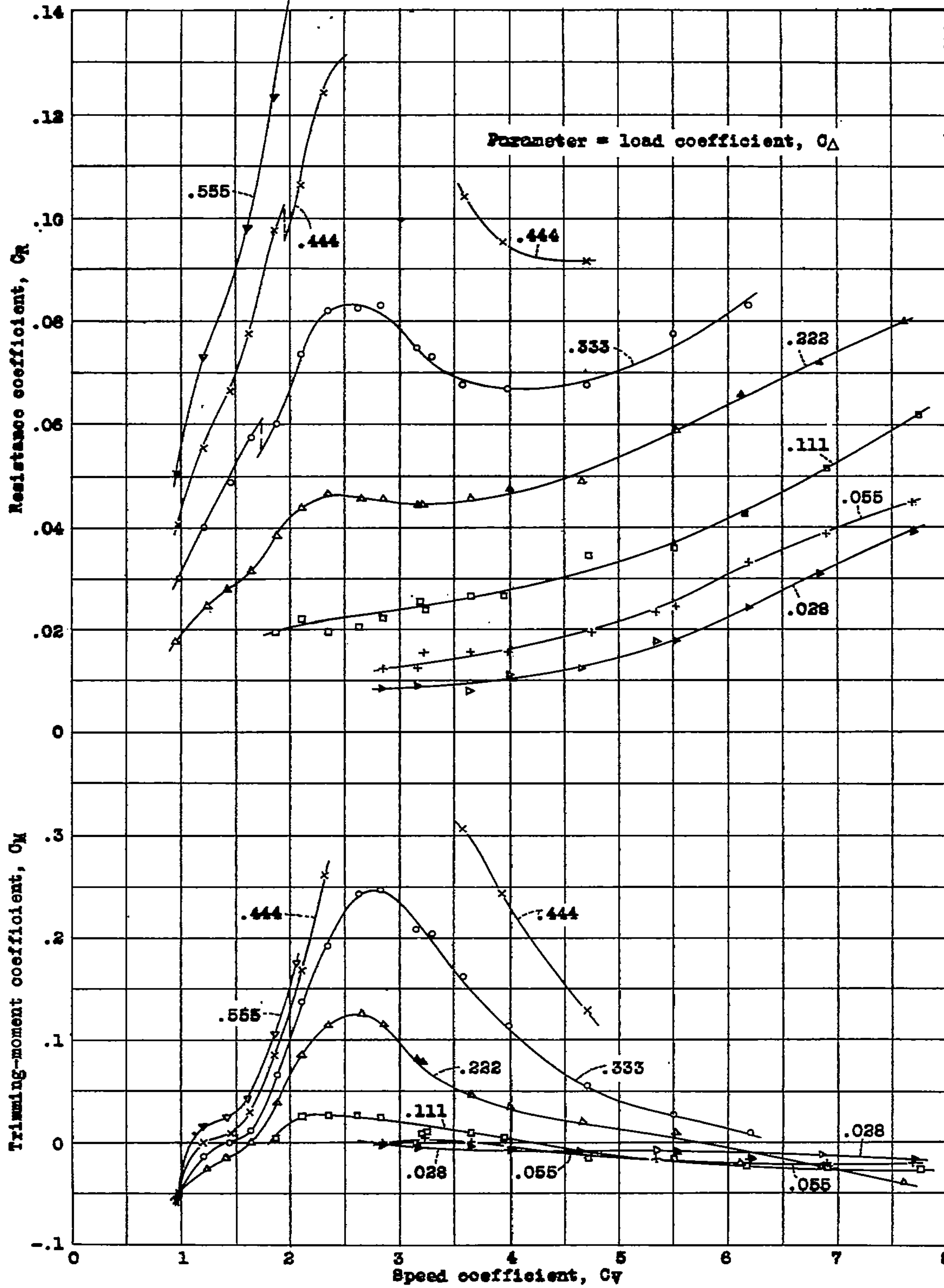


Figure 5.- Variation of C_R and C_M with C_V. $\tau = 4^{\circ}$. Model 44

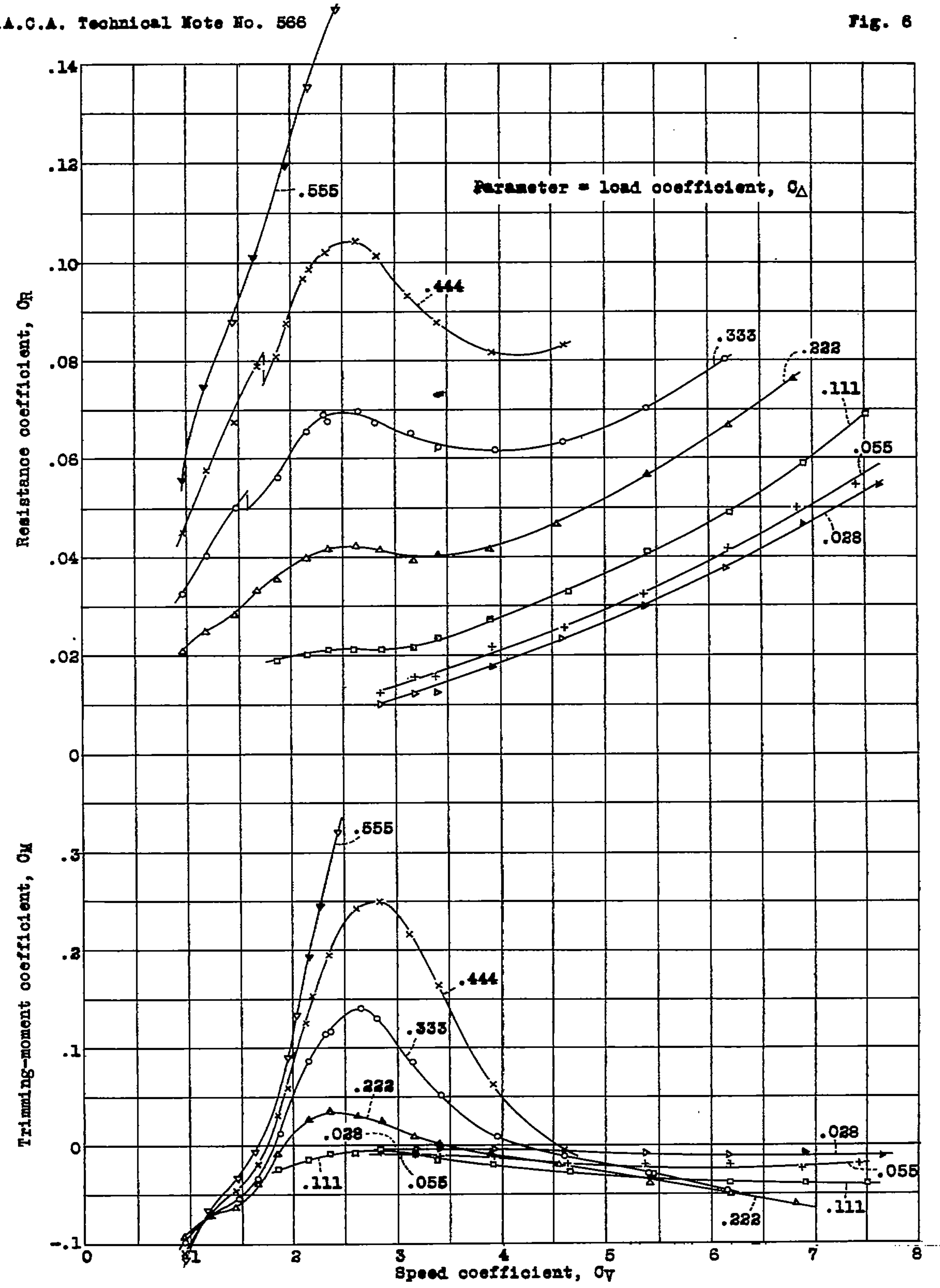


Figure 6.- Variation of C_R and C_M with C_V. $\tau = 6°$. Model 44.

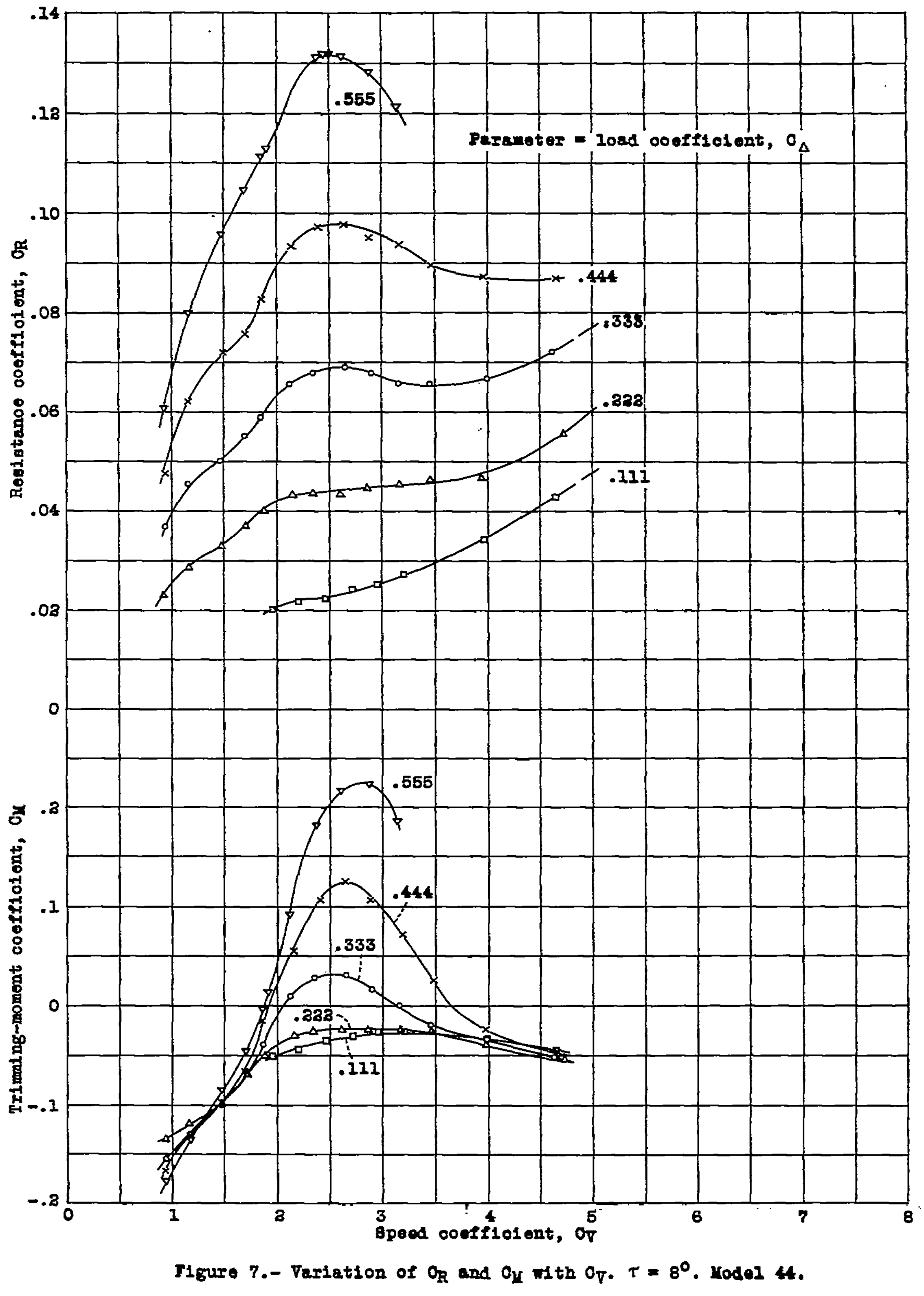


Figure 7.- Variation of C_R and C_M with C_V. $\tau = 8^\circ$. Model 44.

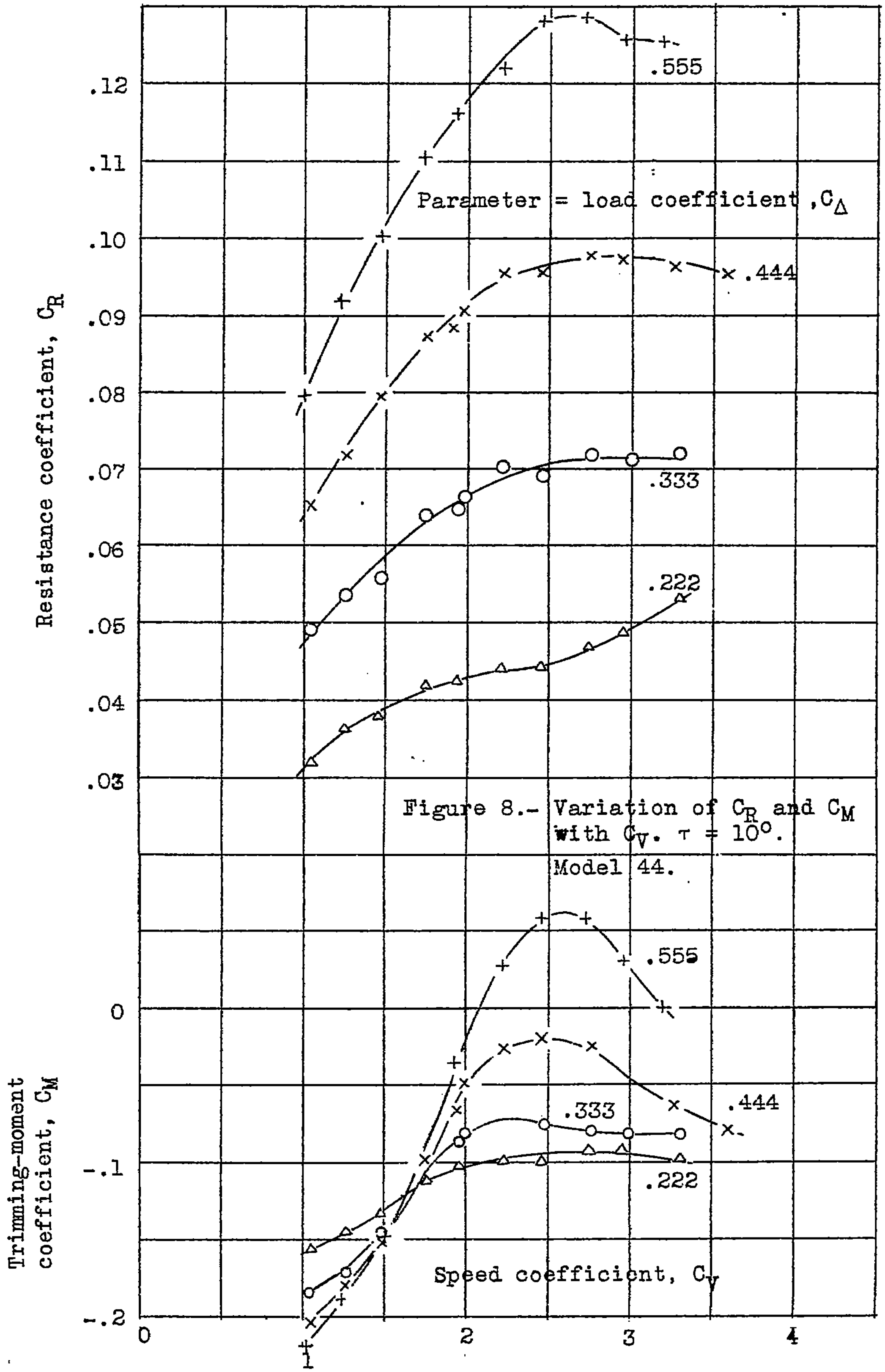


Figure 8.- Variation of C_R and C_M with C_V. $\tau = 10°$. Model 44.

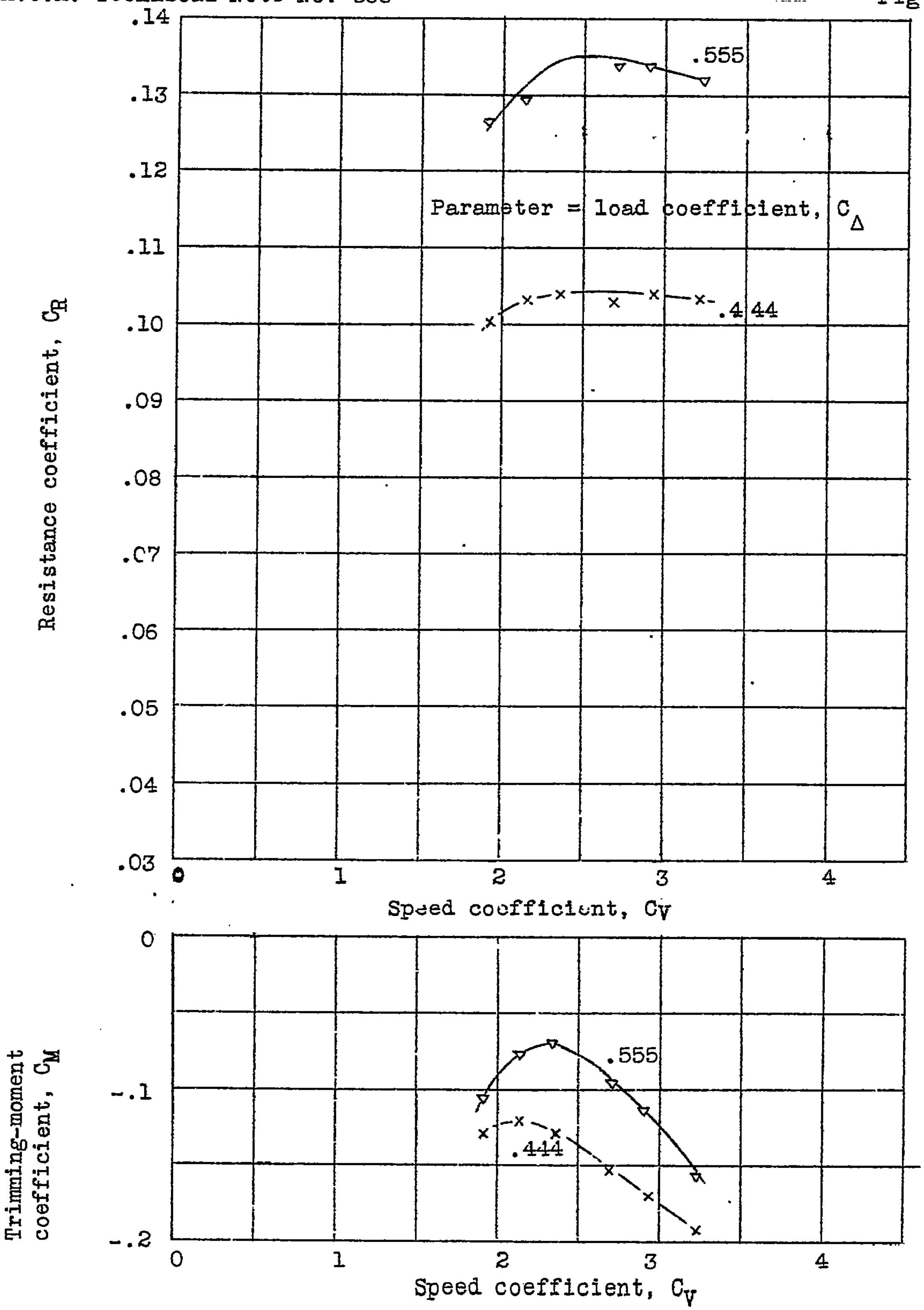


Figure 9.- Variation of C_R and C_M with C_V. $\tau = 12°$. Model 44.

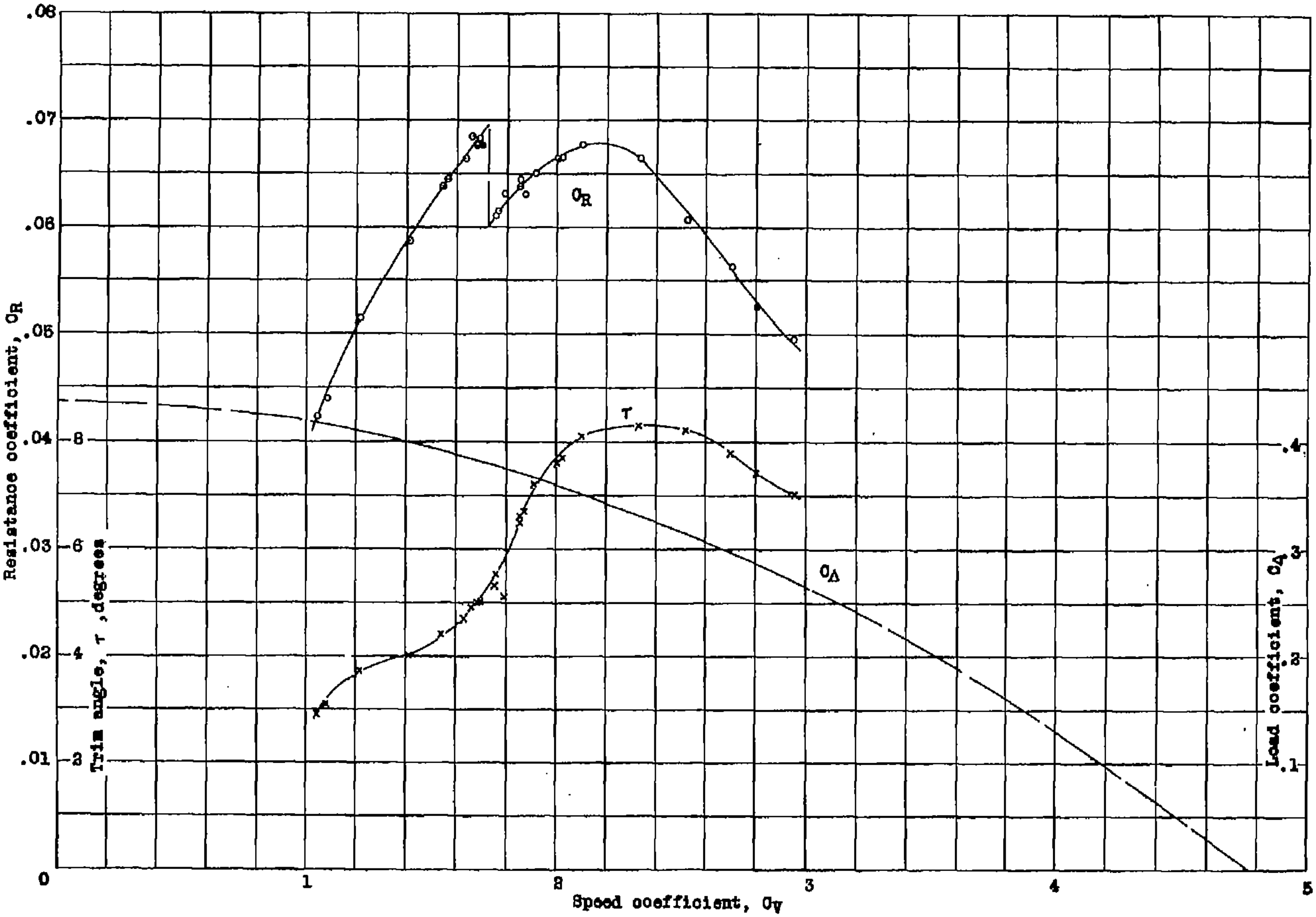


Figure 10.- Free-to-trim test results. Model 44

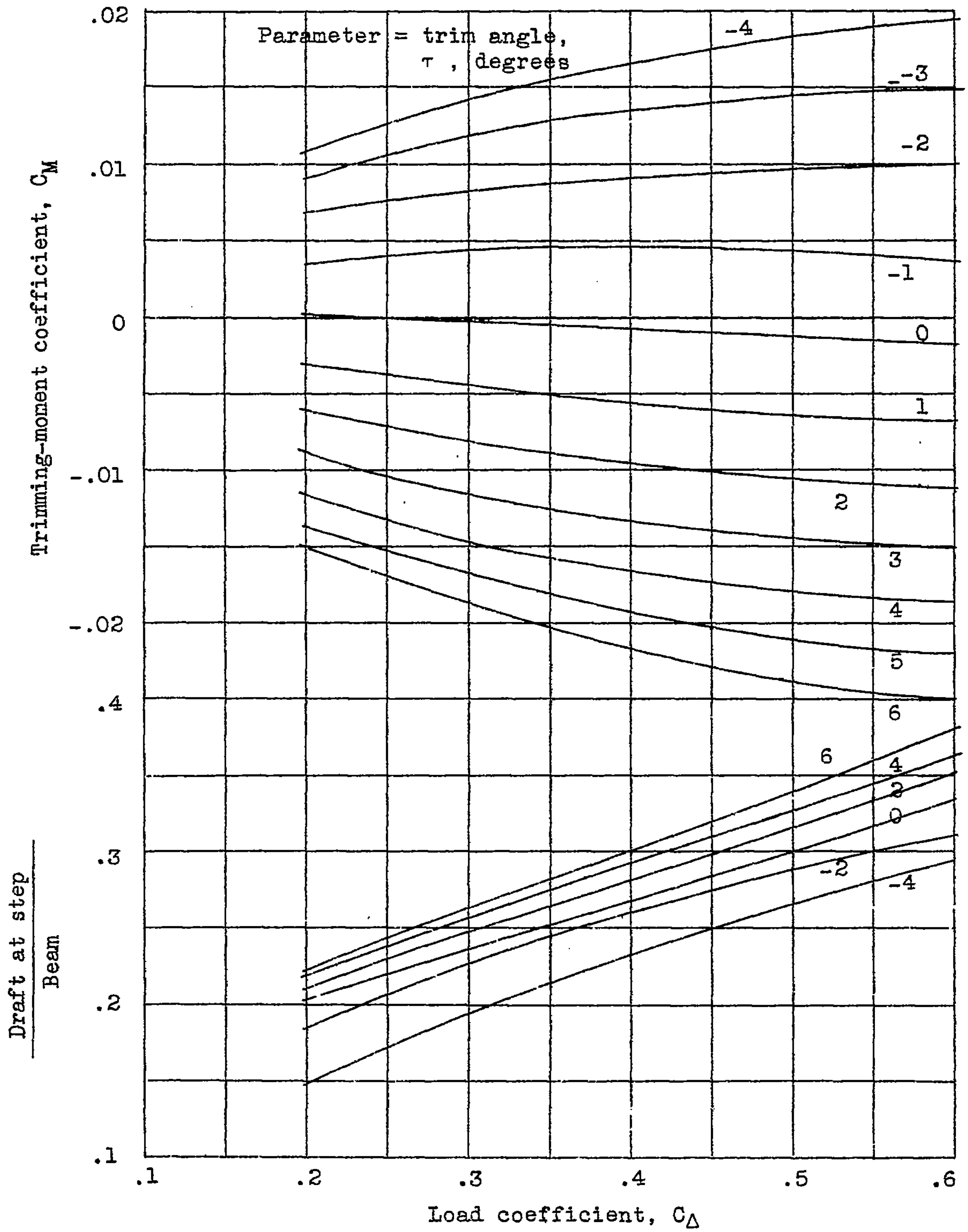


Figure 11.- Trimming-moment coefficient and draft-beam ratio at rest. Model 44.

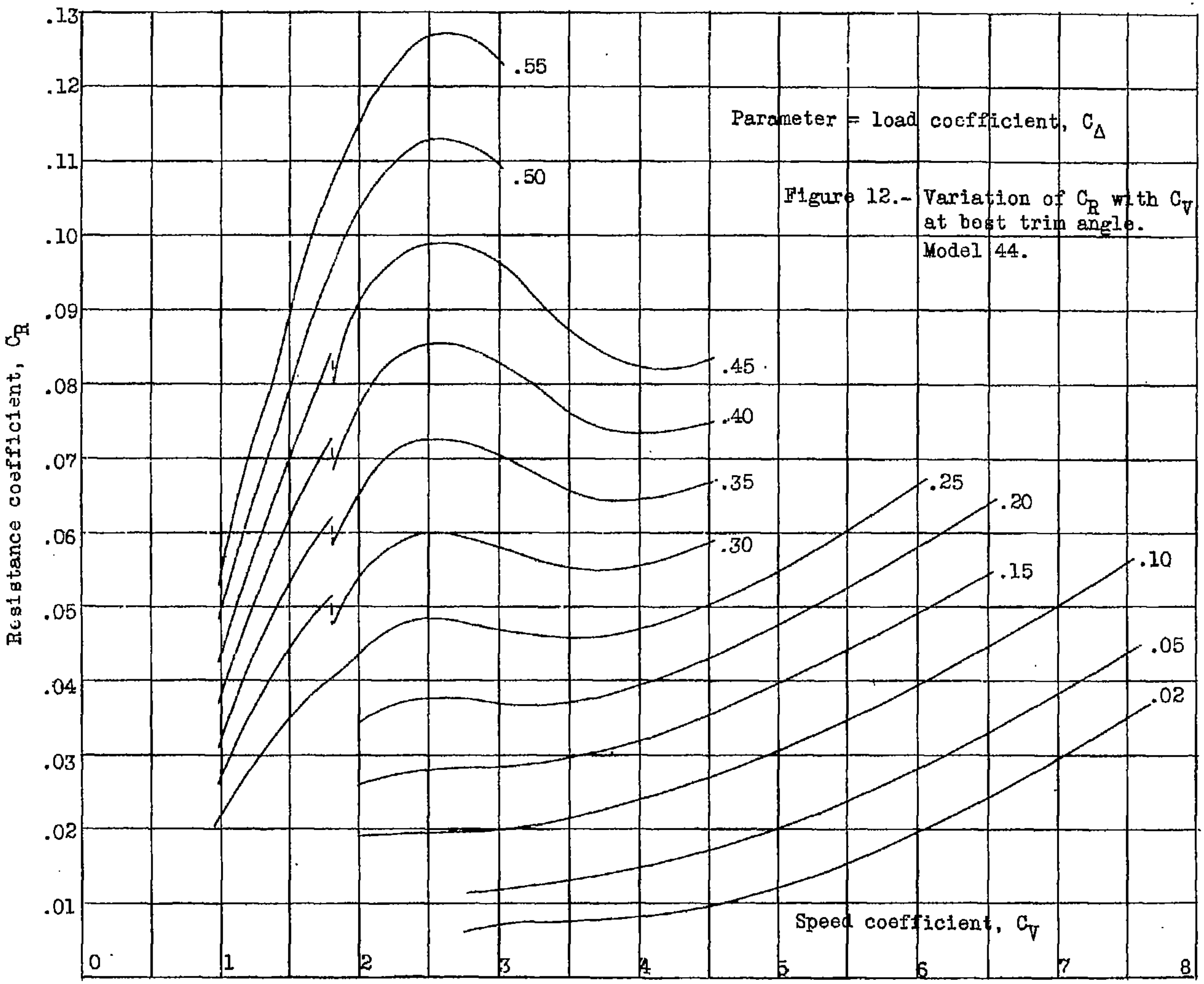


Figure 12.- Variation of C_R with C_V at best trim angle. Model 44.

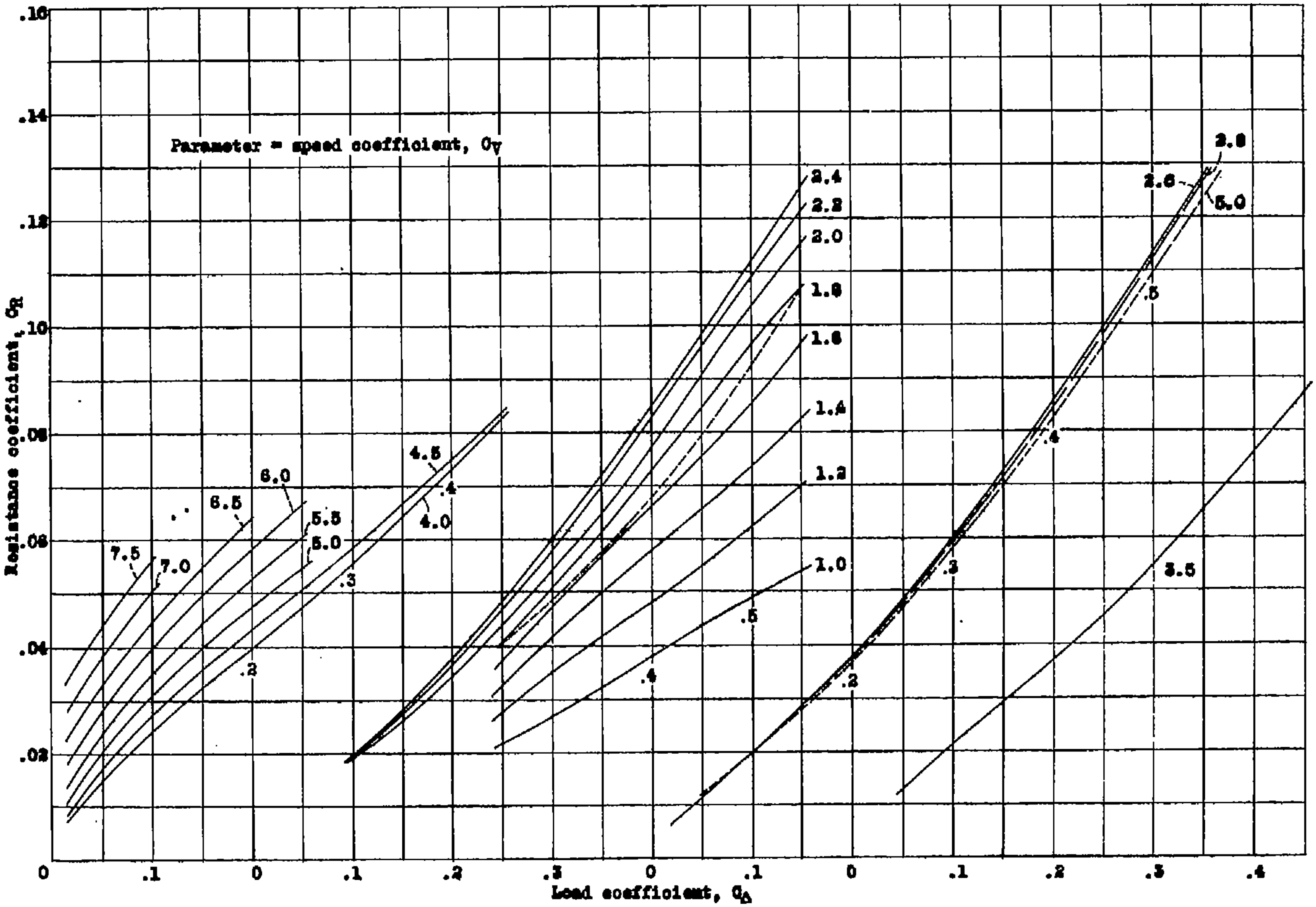


Figure 13.- Variation of C_R with C_Δ at best trim angle. Model 44.

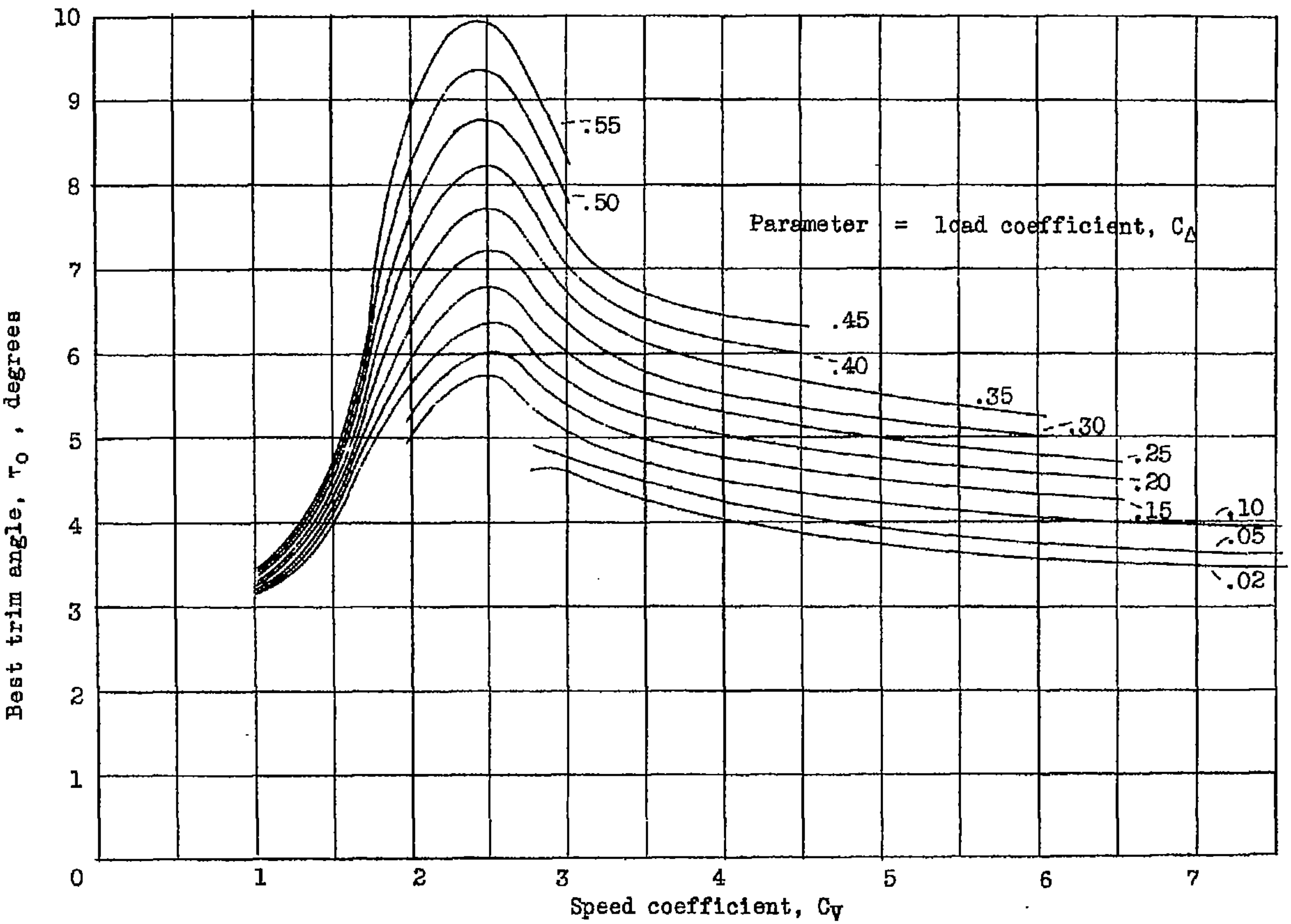


Figure 14.- Variation of τ_o with C_V. Model 44.

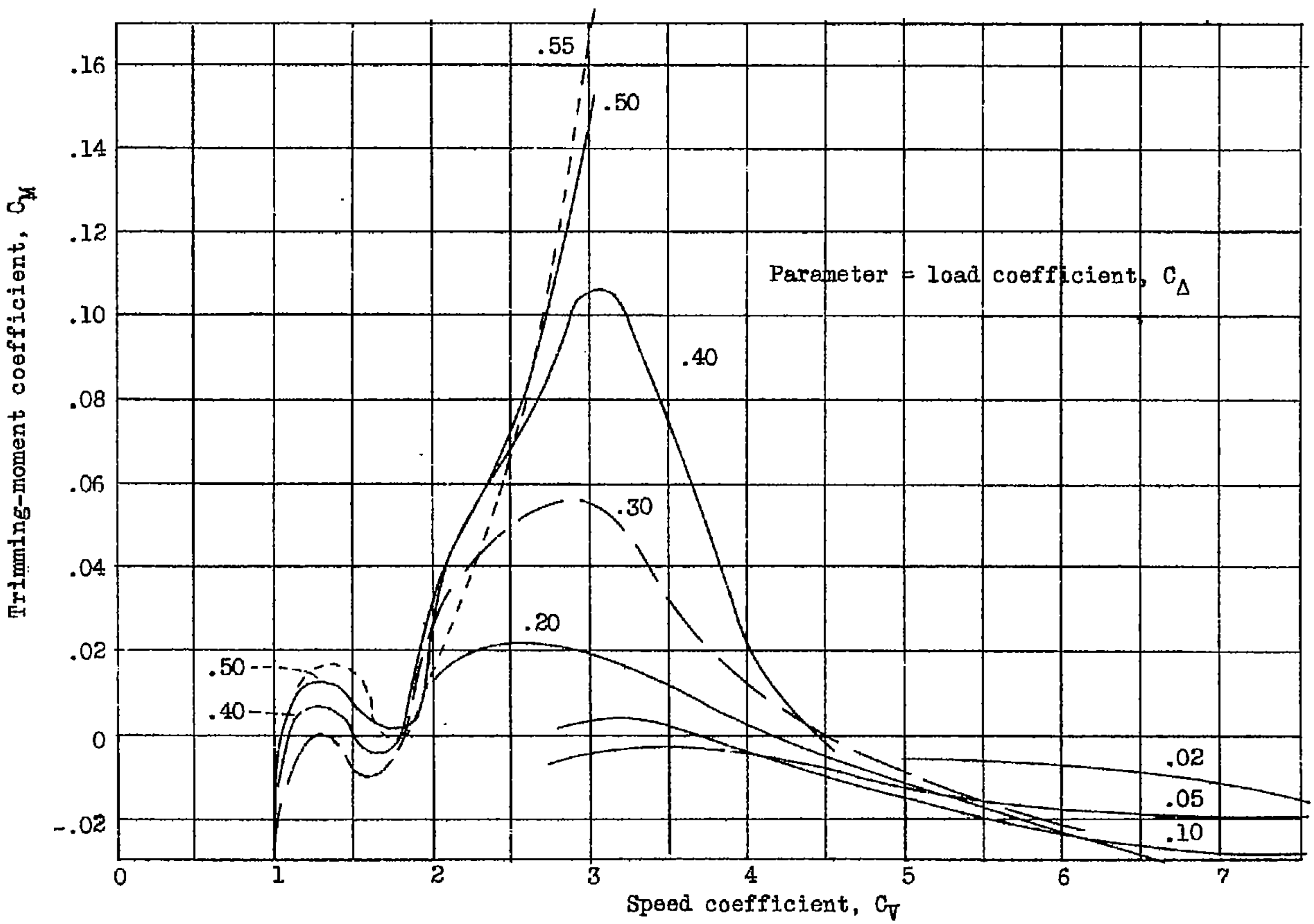


Figure 15.- Variation of C_M with C_V at best trim angle. Model 44.

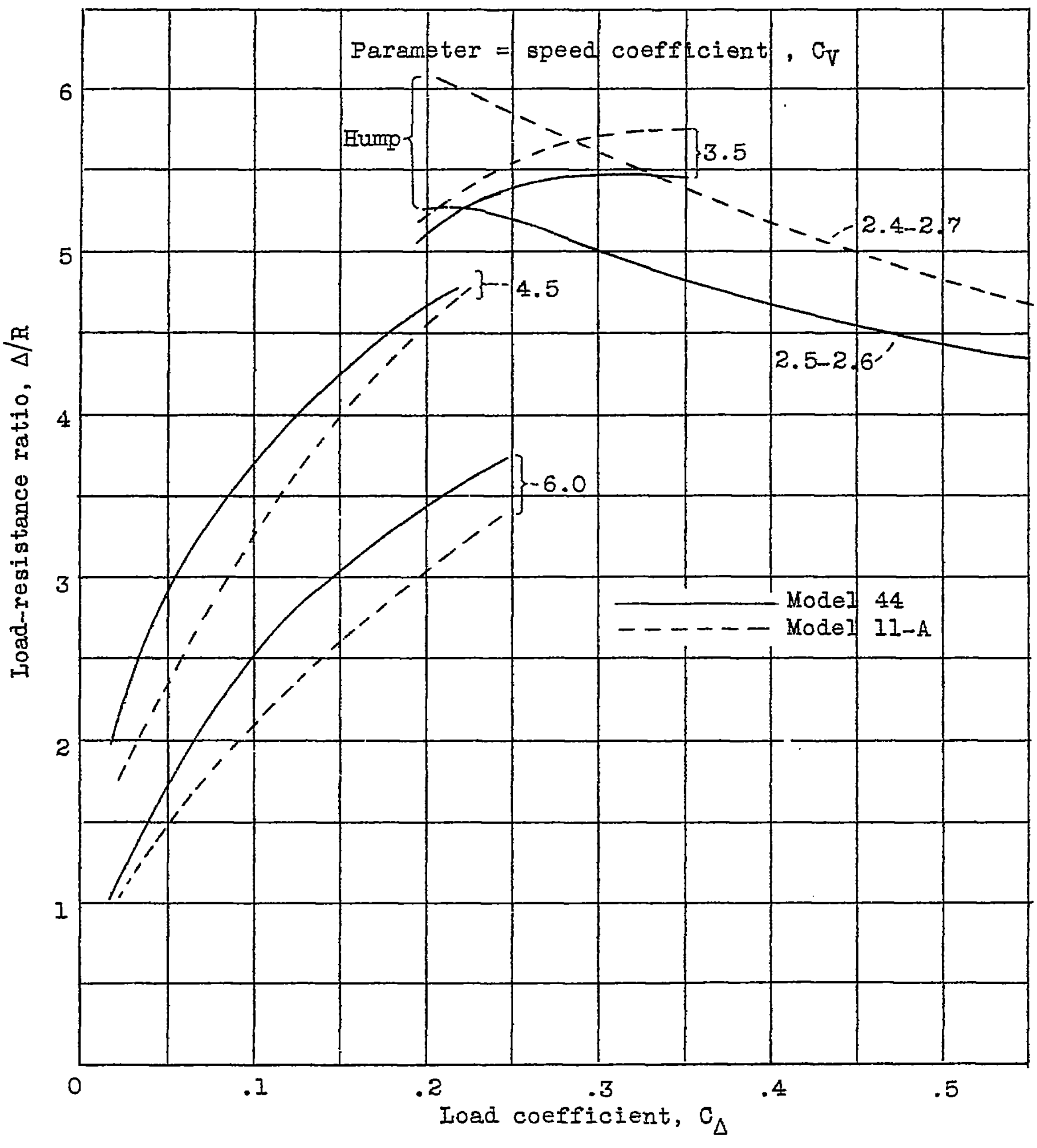


Figure 16.- Comparison of load-resistance ratios of Models 44 and 11-A at best trim angle.

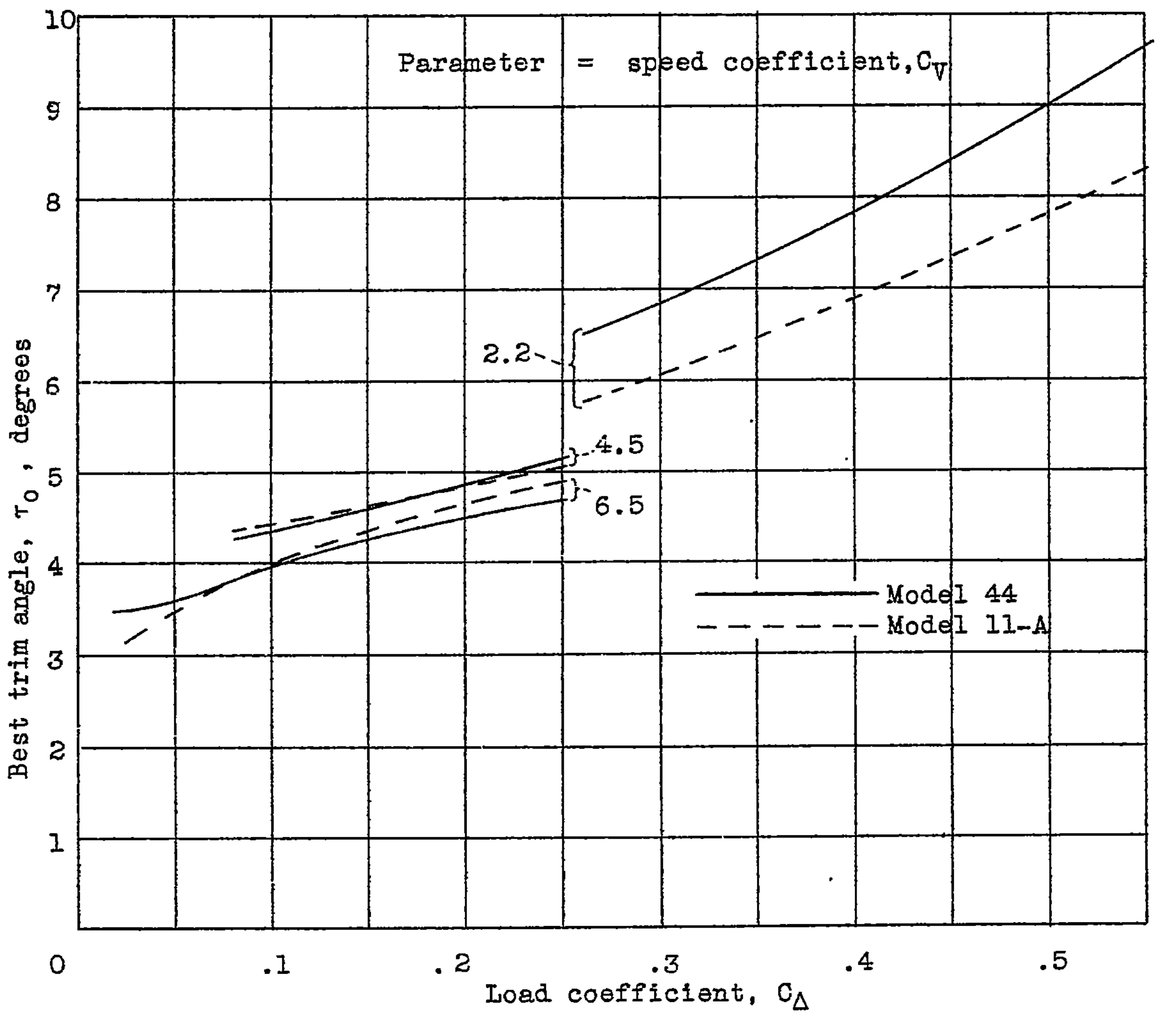


Figure 17.- Comparison of best trim angles of Models 44 and 11-A.

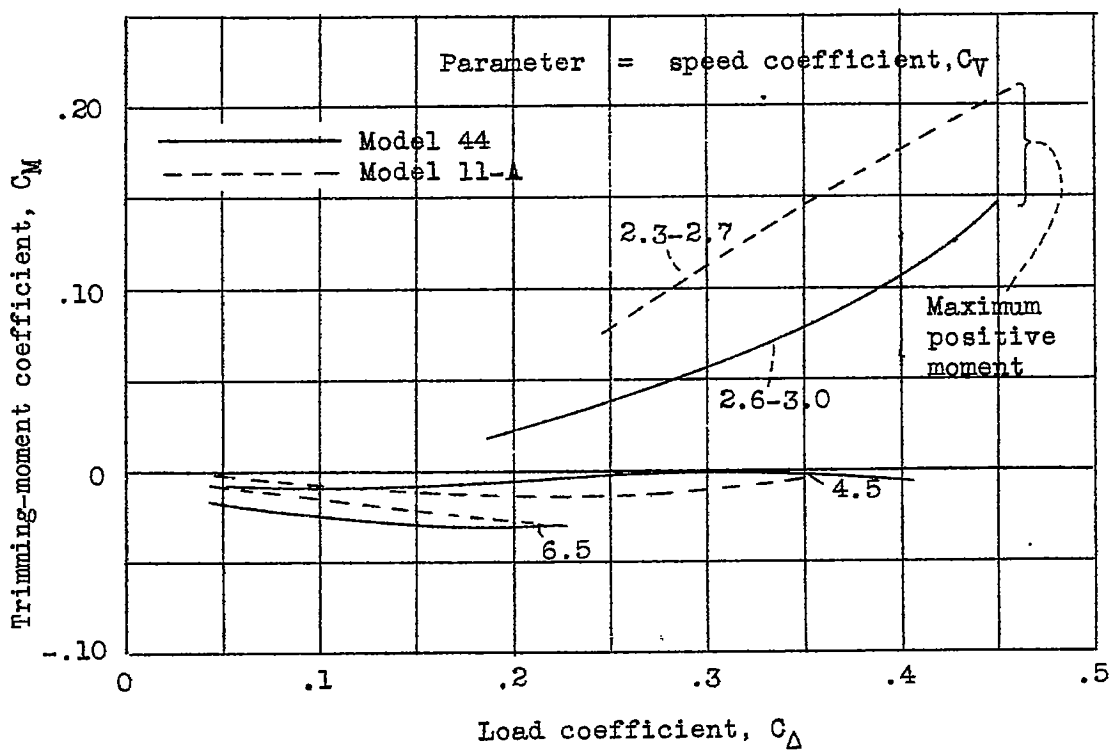
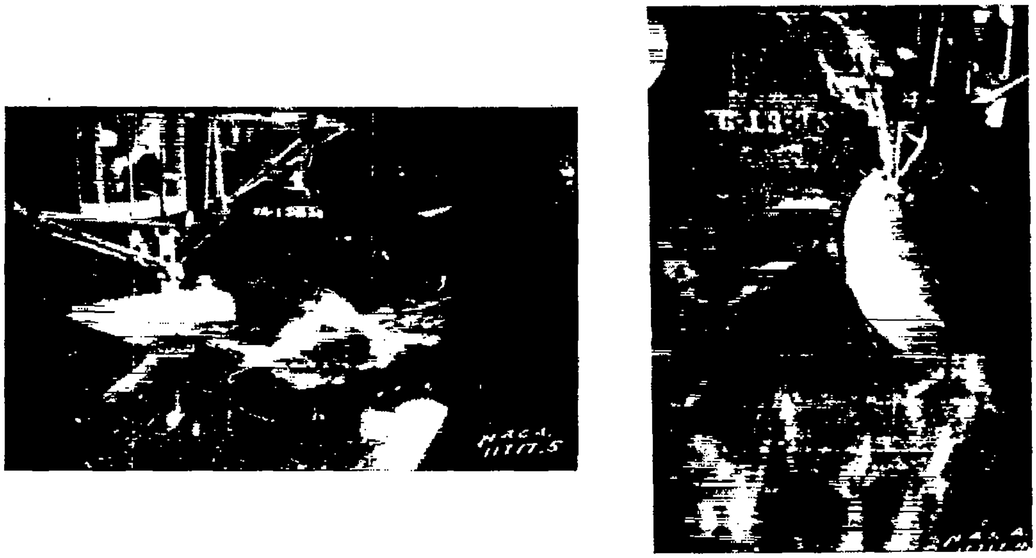
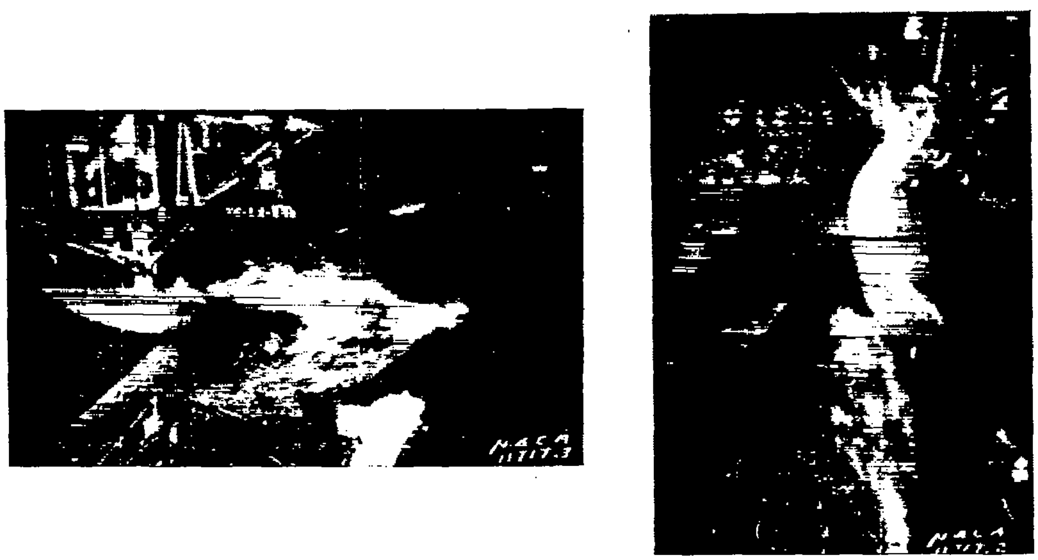


Figure 18.- Comparison of trimming-moment coefficients of Models 44 and 11-A at best trim angle.

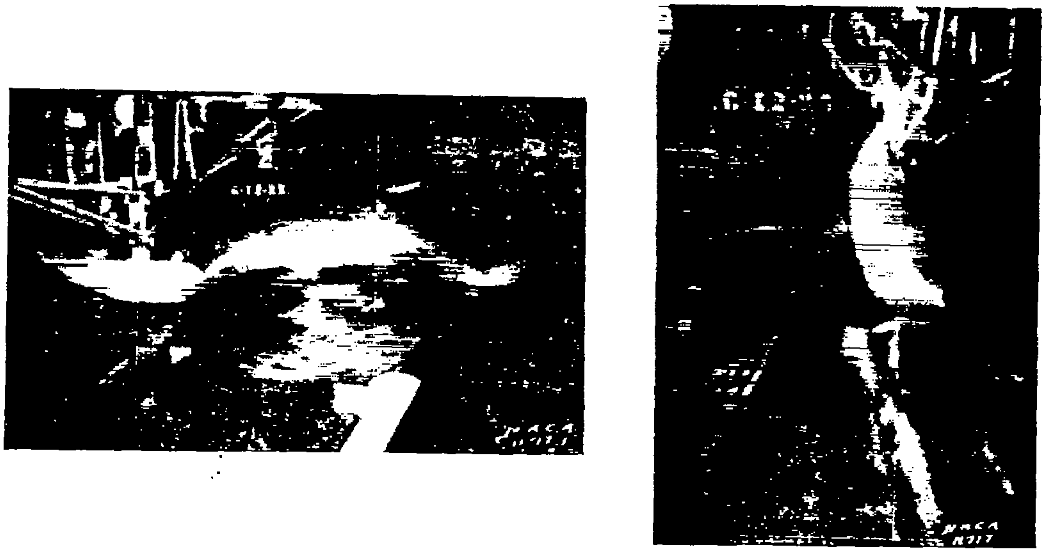


$C_V = 1.35$; $\tau = 3.7^{\circ}$

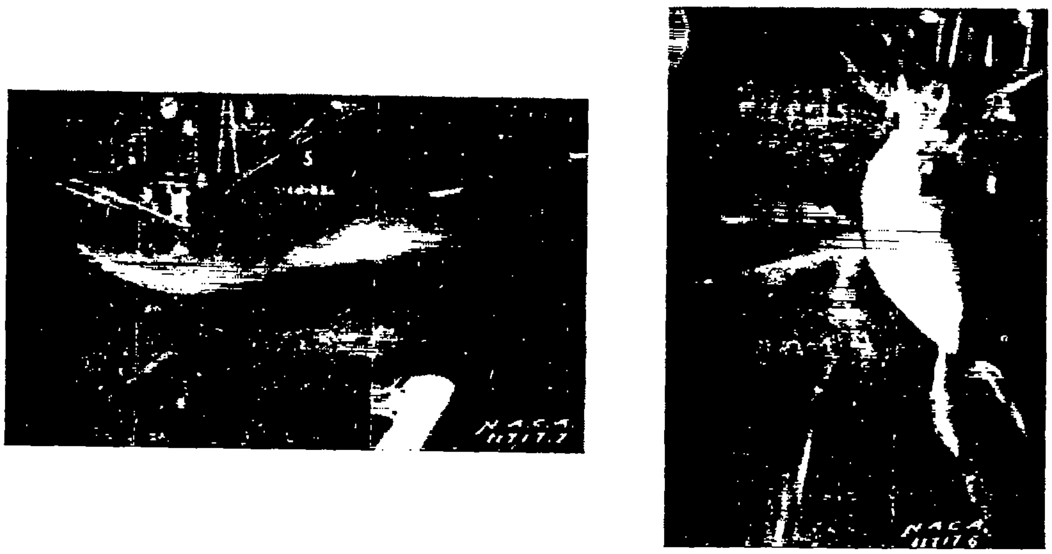


$C_V = 1.66$; $\tau = 4.9^{\circ}$

Figure 19a.- Spray photographs of model 44. Free to trim.



$C_V = 2.00;\ \tau = 7.6^{\circ}$



$C_V = 2.95;\ \tau = 7.0^{\circ}$

Figure 19b.- Spray photographs of model 44. Free to trim.